Setting Asphalt Content For Hot Mix Asphalt

How Much Is Enough?
How Much Is Too Little?

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SKID RESISTANCE

IMPERMEABILITY

STABILITY

FATIGUE RESISTANCE

FLEXIBILITY

WORKABILITY

DURABILITY

1980s
Rut Resistance
Proportions of Material
Property of the Aggregates
Asphalt Content / Imposed Strain
Durability
Environmental Cracking
High Permeability
Leading Cause of Death??

- Rutting
  -❌
- Cracking
  -✔️
Current Durability Concerns

- Mostly Cracking
  - Random and Block Cracking
  - Top Down Cracking
- Some raveling
- Some moisture damage
- Longitudinal Joints continue to be Concern
1960s Age of Cracking

* Strong Emphasis on Cracking
  * Related to Structural Design
    * AASHO Road Test
  * Development of Beam Fatigue Test
1980s Age of Rutting

* National Catastrophe

* Blamed on Asphalt Quality
  * “Taken all the goodies out of asphalt.”

* Led to Strategic Highway Research Program
Implementation of Superpave

- Higher Stiffness Asphalt Binder
  - AC20 (PG64ish)
  - AC10 (PG58ish)
  - PG 70 and PG 76 become more common

- Improved Aggregate Requirements
1990s – 2000s cont’d

* Improved Density Specification
  * “End Result Specifications”
  * 10 to 12% voids moved to 7 to 9% voids

* Volumetric Acceptance
  * Instead of asphalt content and gradation
1990s – 2000s cont’d

* Rutting became Non-Issue (less of an issue)

* Cracking has become the ISSUE
What’s Changed?
Shift from Agency to Industry

* Design, Production and Control shifted to Industry
* Contractor Mix Design
* Plant Settings done by Contractor
Changes since 1990s cont’d

- Increased Use of RAP

- Introduction of Shingles
  - Very limited in 1990s
  - Today
    - Commonly used in many States
Asphalt Binder Additives

- Recycled Engine Oil Bottoms
  - Mostly used for Lower Temperature Grades
- Reported to cause cracking
  - Investigations continue
Changes since 1990s cont’d

- Asphalt Binder Additives
  - Polyphosphoric Acid
    - Common in early 2000s
  - Polymer Modified Become More Common
    - SBS was most common (only) polymer used
    - Modified Asphalt was relatively new
What are people saying?
“Causes of Cracking”

* Too much RAP
* Need to limit (ban) RAS
* REOB is cause
* Asphalt mixes are “Too Dry”
SOLUTIONS?
Reduce design gyrations

Wrong

* True only IF gradation is held constant AND gyrations are reduced
  * VMA will increase
  * 25 gyrations ≈ 1.0% VMA
* BUT gradation is not a design criteria
Common “Solutions” to Increase Asphalt Content

* Reduce design air voids
  * i.e. 3.0% air voids would increase asphalt content 0.4%

* BUT
  * Make sure controls are in place to hold VMA at the previous design levels.
    * Otherwise change gradation and reduce air voids without increasing asphalt content.
Common “Solutions” to Increase Asphalt Content

* Increase design VMA criteria
  * 1.0% VMA ≈ 0.4% asphalt content

* The only real way to increase asphalt content.
* Increasing VMA will increase
  * Total asphalt content
  * Effective asphalt content
Common “Solutions” to Increase Asphalt Content

* Require use of fine-graded mixes
  * “Contractors are designing their mixes on coarse side to reduce the amount of asphalt they need.”

* Asphalt content is set on basis of VMA minus air voids plus absorbed asphalt.
Common “Solutions” to Increase Asphalt Content

* Use deduct factor for RAP and RAS
  * i.e. for RAS set binder content at 70% of RAS binder
  * “Reduces the amount of RAS binder”

Wrong

* i.e. 12% asphalt binder replacement desired from RAS
* With 100% contribution
  * 3% RAS with 20% asphalt binder
    * RAS binder is 0.6%
    * Total Binder is 5.0%
Common “Solutions” RAS cont’d

* With 70% contribution
  * Percent RAS increased
    * 4.3% RAS added
    * 0.7 x 0.86% RAS binder = 0.6%
    * Virgin binder 4.4%
    * “Total” binder = 5.0%
  * Perceived ABR = 12%
  * Actual ABR = 0.86 / 5.26 = 16.3%
How Much Asphalt is Enough?

- Two Part Answer
- Asphalt on Outside of Aggregate
- Asphalt Absorbed into Aggregate
How Much Asphalt is Enough?

- Asphalt Outside of Rock
  - Based on Volume

<table>
<thead>
<tr>
<th></th>
<th>9.5-mm</th>
<th>12.5-mm</th>
<th>19.0-mm</th>
<th>25.0-mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent by Volume</td>
<td>11.0%</td>
<td>10.0%</td>
<td>9.0%</td>
<td>8.0%</td>
</tr>
<tr>
<td>Percent by Weight</td>
<td>4.4%</td>
<td>4.0%</td>
<td>3.6%</td>
<td>3.2%</td>
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</tbody>
</table>
How Much Asphalt is Enough?

- Asphalt Inside of Rock
  - Depends on Absorption

<table>
<thead>
<tr>
<th>Aggregate Water Absorption</th>
<th>1.0%</th>
<th>2.0%</th>
<th>3.0%</th>
<th>4.0%</th>
<th>5.0%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt Percent by Weight</td>
<td>0.5%</td>
<td>1.2%</td>
<td>1.9%</td>
<td>3.0%</td>
<td>4.0%</td>
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</tbody>
</table>
How Much Asphalt is Enough?

* Total Asphalt Content
  * Inside Rock
  * Outside Rock

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<th>12.5-mm</th>
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<th>25.0-mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%</td>
<td>4.9%</td>
<td>4.5%</td>
<td>4.1%</td>
<td>3.7%</td>
</tr>
<tr>
<td>2%</td>
<td>5.6%</td>
<td>5.2%</td>
<td>4.8%</td>
<td>4.4%</td>
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<tr>
<td>3%</td>
<td>6.3%</td>
<td>5.9%</td>
<td>5.5%</td>
<td>5.1%</td>
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<tr>
<td>4%</td>
<td>7.4%</td>
<td>7.0%</td>
<td>6.6%</td>
<td>6.2%</td>
</tr>
<tr>
<td>5%</td>
<td>8.4%</td>
<td>8.0%</td>
<td>7.6%</td>
<td>7.2%</td>
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</tbody>
</table>

These values are approximate and will vary depending upon specific gravity of aggregates and actual absorption.
THANK YOU